Investigation on Performance of Natural Fillers reinforced Glass Polymers as acoustic enclosure on 2kVA Portable electric generator

[1]B.Ram Kumar, [2]Dr.Dharmendra Dubey

[1] PhD Research Scholar, [2]Professor
[1]Department of Mechanical Engineering ,
[1]Bhagwant University, Ajmer-305004, Rajasthan

***Abstract*— Electric power is a major driver of any nation economy which opens viable and veritable investment opportunities to government, corporate bodies and private individual. A novel product of engineering invention developed to provide continuous electric power is a device known as electric generator. The machine combines the knowledge, skills and training of mechanical, electrical and chemical engineering disciplines to develop a fossil fuel based engine which convert the chemical energy to mechanical energy and then to electrical energy. The by-products of the operation of this devise are an emission in the form of CO gas and noise which create environmental hazards and constitutes challenging global menace such as greenhouse effect and disability in man. We investigate on acoustic enclosure performance with 2kVA generator which is used widely. Acoustic enclosures are made with Natural filler reinforced glass polymers as base material and their Sound Reduction Index(SRI) were studied.**

***Key words*— GFRP, Egg shell, Prosposis Julifora, Sugarcane bagasse (SCB), Water Hyacinth, Human hair, acoustic enclosure, Sound Level Meter,Sound Reduction Index, NIOSH,OSHA.**

I. Introduction

Wherever noise is a problem, there are three orders of priority for dealing with it. Within each of these there are various options available that form a simple hierarchy of control. Noise can be reduced by controlling at source, attenuating noise transmission, controlling noise exposure at the receiver.

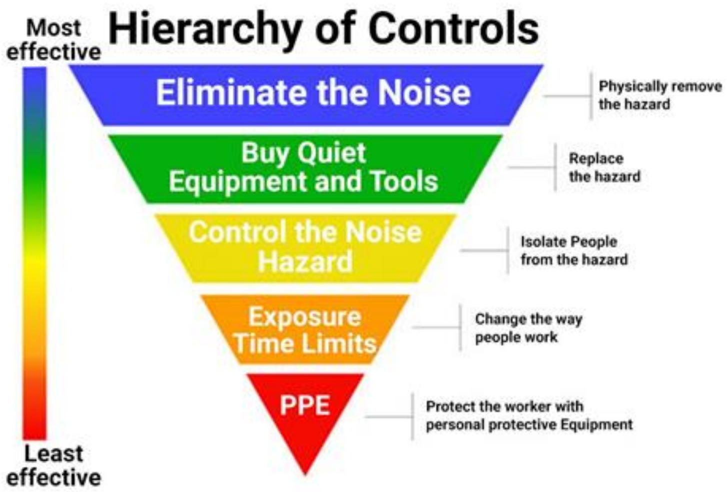

Fig.1: Hierarchy of Noise Control

When sound strikes a surface (such as a wall), several things can happen. Depending on the properties of the material (the material of which the wall is made) and the characteristics of the noise, a proportion will be reflected from the surface, some will be absorbed by the surface and some transmitted through the surface. The following figure illustrates the interaction of a sound wave front with a slab of material and its reflection, absorption and transmission.

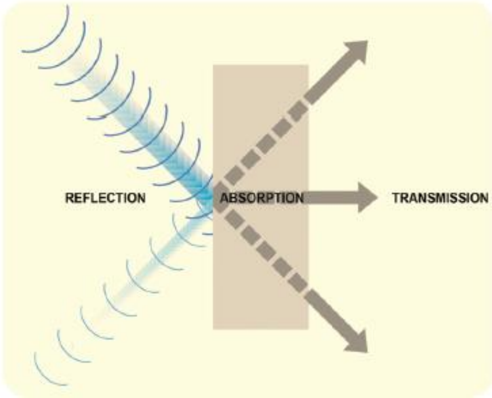

Fig.2: Interaction of a sound wave front with a slab of material and its reflection, absorption and transmission

II. NOISE ENCLOSURE

In many cases, the best method of noise control is to enclose the noise source. To be effective, enclosures must be airtight; the smallest gap allows sound to escape and reduces the attenuation of the noise inside the enclosure. This is a particular problem with, for example, woodwork machines, such as saws and planes, where timber is fed in at one end and comes out at the other. However, such equipment can be fitted with noise-reducing[1] feed, and delivery tunnels fitted with windows to allow clear viewing and with adequate lighting. Machinery enclosures should be mounted so that they do not transmit noise and vibrations to the floor.

Dense high-mass materials are good sound insulators. They include brick, concrete, heavy-gauge steel and plaster. However, in order to absorb noise and reduce reflections from walls, low-density porous materials are required, such as mineral fibre and acoustic tiles. Acoustic enclosures, therefore, have a heavy noise-reflecting outer skin and a noise-absorbent lining, such as mineral fibre. A typical enclosure wall is shown in the following figure:

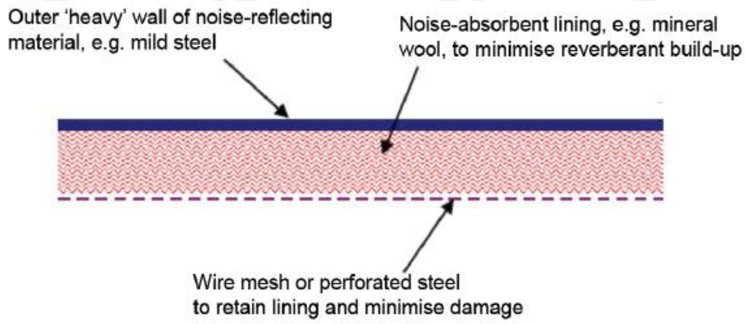

Fig.3:Structure of the wall of a noise enclosure

The amount of noise reduction or attenuation offered by the enclosure is measured by the difference in sound levels before and after the enclosure (or any other form of control) is fitted. A good enclosure will reduce noise levels by between 10dB(A) and 30dB(A).

There are also design and operational issues to consider. These include maintenance and access considerations which, if ignored, will result in doors being left open or panels permanently removed. Key design features include:

- Sound reduction index of the panelling of the enclosure.
- Protection of the internal absorbent lining.
- Robust construction.
- Sealing between panel and floor, and around penetrating ducts and pipes.
- Access for operation and maintenance.
- Robust locks to doors and hatches.
- Observation windows.
- Adequate internal space.
- Adequate lighting and ventilation.

Sound Reduction Index (SRI) : This is the difference, in decibels (dB), between the sound level incident on a material and the sound level transmitted through the material, i.e. the level of attenuation (sound reduction) of noise. It is an idealised laboratory measurement of sound insulation (i.e. sound reduction) properties; real world measurements can differ (transmission through floor, etc.). SRI is also known as transmission loss. For example, a wall made of eight-inch hollow concrete blocks has a transmission loss of 58dB at 2kHz. In other words, the sound intensity at the 2kHz frequency is reduced by 58dB by passage through the wall. In general, the denser the barrier material, the higher the transmission loss.

Measurement of Noise : Noise is measured in units of sound pressure levels called decibels, named after Alexander Graham Bell, using A-weighted sound levels (dBA). The A-weighted sound levels closely match the perception of loudness by the human ear. Decibels are measured on a logarithmic scale which means that a small change in the number of decibels results in a huge change in the amount of noise and the potential damage to a person's hearing.

OSHA sets legal limits on noise exposure in the workplace. These limits are based on a worker's time weighted average over an 8 hour day. With noise, OSHA's permissible exposure limit (PEL) is 90 dBA for all workers for an 8 hour day. The OSHA standard uses a 5 dBA exchange rate. This means that when the noise level is increased by 5 dBA, the amount of time a person can be exposed to a certain noise level to receive the same dose is cut in half.

The National Institute for Occupational Safety and Health (NIOSH) has recommended that all worker exposures to noise should be controlled below a level equivalent to 85 dBA for eight hours to minimize occupational noise induced hearing loss. NIOSH has found that significant noise-induced hearing loss occurs at the exposure levels equivalent to the OSHA PEL based on updated information obtained from literature reviews. NIOSH also recommends a 3 dBA exchange rate so that every increase by 3 dBA doubles the amount of the noise and halves the recommended amount of exposure time.

NIOSH Recommended exposure limit (REL) Vs OSHA Permissible Exposure Limit (PEL) : The US National Institute for Occupational Safety and Health (NIOSH) has a recommended standard for all industries (Centers for Disease Control and Prevention/NIOSH publication 98-126).This standard specifies an 85 dBA Recommended Exposure Limit (REL), and makes specific recommendations on the key elements of an effective hearing conservation program. The NIOSH standard is consistent with the exposure guidelines used by most scientific and regulatory bodies internationally, but NIOSH is not a regulatory agency and thus the standard is not mandated by law. It is designed to represent best scientific practice. The US Occupational Safety and Health Administration (OSHA) exposure limit is regulatory - this is law and must be complied with. The NIOSH and OSHA limits are the two commonly used in the United States.

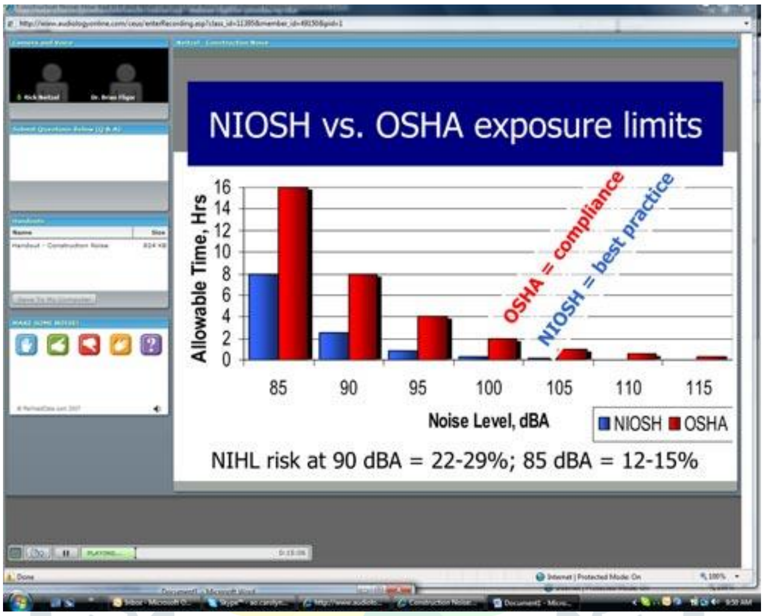

Fig.4: NIOSH Vs. OSHA Exposure limits

The graph below compares these two limits. As you can see, OSHA permits a worker to be exposed to 85 dBA for an allowable time of 16 hours per day. The NIOSH recommended allowable time for 85 dBA is 8 hrs per day. In addition to using a lower exposure limit than OSHA, the NIOSH standard uses a more protective 3 dB exchange rate that results in shorter allowable exposures at high noise levels than those of the OSHA regulation. For example, OSHA permits an exposure to 105 dBA for one hour per day, while NIOSH recommends that such an exposure last less than five minutes. Hearing conservationists may be surprised to learn that neither the OSHA nor NIOSH limit is designed to protect every worker from suffering any NIHL. However, the NIOSH standard is the more health-protective limit of the two. For example, NIOSH estimates that approximately one in four workers exposed at the 90 dBA OSHA PEL eight hours per day over a 40 year working lifetime will suffer a compensable hearing loss from noise, compared to only about one in twelve workers exposed at the 85 dBA NIOSH REL.

III. MATERIALS AND METHOD OF CONSTRUCTION

The enclosure is made of six panels of the same composition designed to insulate the noise from the outside environment at minimum weight and cost. The degree of reduction is enhanced by the use of the panel on all sides of the enclosure. The heat is dissipated through the vents created on the right and left sides of the Polyurethane acoustic foam (7.50 mm), GFRP with natural filler (15.0 mm) and plywood (10.0 mm) Materials for the components of the panel were sourced locally with the aim of enhancing availability and improve affordability.

A portable 2kVA electric power generator[2] rated 950 W/220 V, 18 kg weight and 370×330×320 mm dimension (L×W×H) was considered. Six walls made of designed acoustic panel were constructed for the enclosure. A slider was introduced at the base to serve as the base to ease the placement of the generator inside the enclosure. Sufficient clearance was provided between the generator and the enclosure for necessary circulation of air. This is assisted by four bores that were created on the slider to accommodate the shoes to fix the generation in a position and minimise movement of resulting from vibration. To avoid the risk of explosion and fire hazard that could result from excessive heat exposure during the operation of the generator the fuel (gasoline) tank was isolated from the generator and mounted on the top of the enclosure. Vents were made on the sides of the enclosure to convey heat away from the enclosure. An extension pipe was designed and made to serve as passage for exhaust gases from the enclosure. The outside dimension of the enclosure is

440×440×440 mm To enhance heat absorption, the inner galvanised sheet metal was coated with black paint. The noise level measurement was carried out using NIOSH App (on Apple iPhone 11).

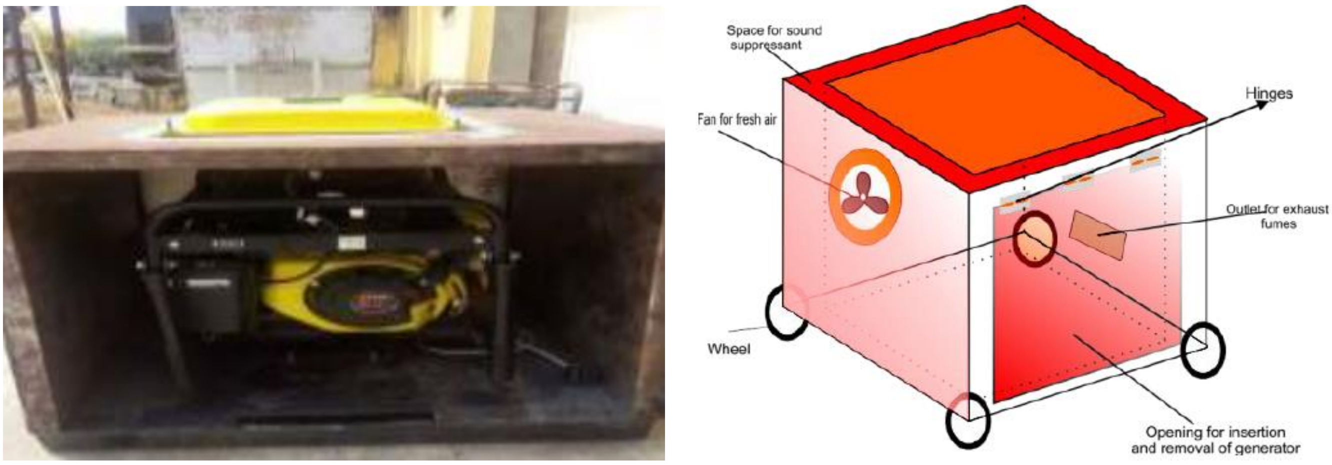

Fig.5: Enclosure and 2KVA Electric Power Generator; Model of enclosure for petrol generator

IV. TAKING NOISE MEASUREMENT :

The sound level meter used must be a Class 2 integrating sound level meter (or better), with an in-date certificate of test and a suitably tested calibrator. Dosimeters might be used where workers move around in the workplace, preventing the measurement of exposure at static locations.

Several different categories of instrument are available, such as Simple Sound Level Meters (SSLMs), Integrating Sound Level Meters (ISLMs). Personal Sound Exposure Meters (Dosimeters) depending of the application of usage.

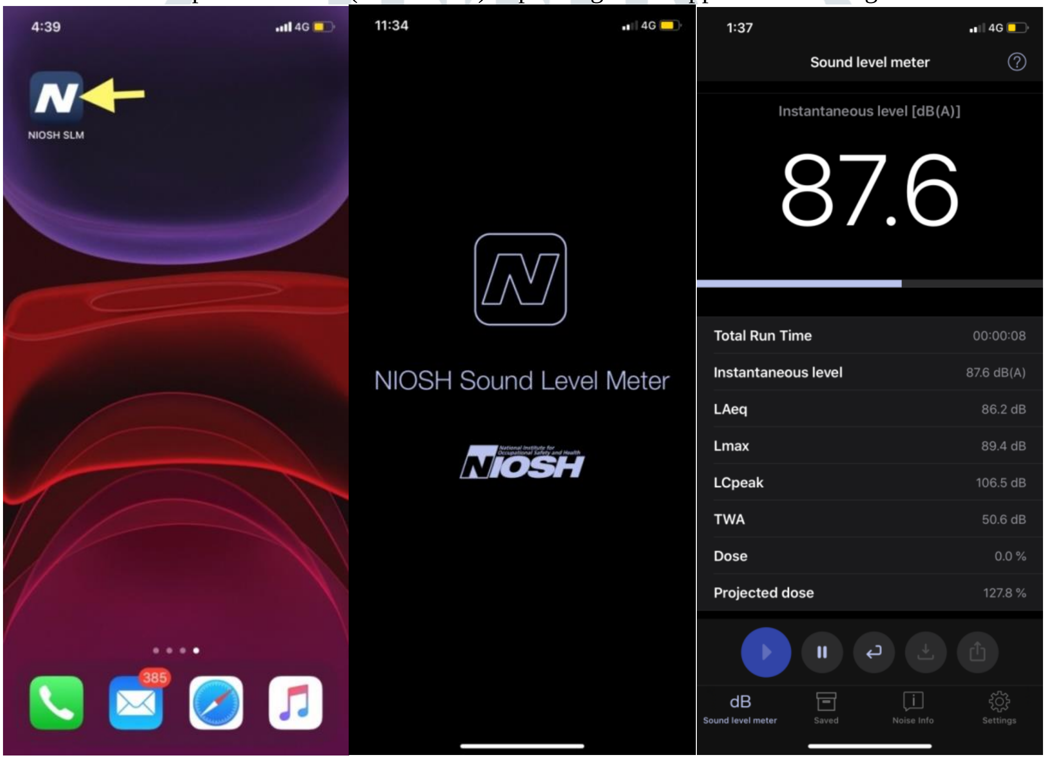

Fig.6:NIOSH Sound Level Meter – iOS App in iPhone 11

Here in our investigation of performance of acoustic enclosure , NIOSH Sound Level Meter(SLM) App for iOS was used to measure A-weighted sound level. The NIOSH SLM app has many important features, it provides a readout of the sound level using the built-in microphone (or external microphone if used) and reports the instantaneous sound level in A, C, or Z-weighted decibels. The App is as reliable as actual sound level meter device.

The meter was directed towards noise source and located from various distances. For evaluation of the effectiveness of the enclosure sound level were measured and recorded for

1. Ambient condition,
2. Generator noise without enclosure and
3. Noise with generator inside the enclosure.

The weighting is user-selectable and can be accessed in the "Settings" screen. The app also reports the main metrics that are of importance for proper occupational noise measurements – mainly the run time (total time), the A-weighted Equivalent Sound Level (LAeq), the Maximum Level measured during the current run time, the C-weighted Peak Sound Pressure Level (LCpeak), the Time-Weighted Average (TWA) and Dose.

The app also contains some basic information on noise and hearing loss prevention. In addition, the app allows the user to save and share measurement data using the smartphone other communication and media features. If location services are enabled, the app can utilize the GPS feature to provide an exact geospatial location of the location of the noise measurement

Three different times of the day (7-9 am, 1–3 pm, 8–10 pm) were considered to monitor the contributions of environmental noise due to other activities taking place around the location of the generator. The effect of loading on the noise level variation[3] were also recorded for on and off loading at all the time frames considered for the experiment.

Time	Minimum dB(A)	Maximum dB(A)	Average dB(A)
7a.m- 9a.m (Morning)	34.5	49.9	42.3
1p.m – 3p.m (Afternoon)	43.9	54.5	47.0
8p.m – 10p.m (Evening)	45.4	50.5	46.6

Table 1: Ambient Noise measurement

Thermal conditions of the enclosure through the monitoring of the heat generated in the inside during the operation of the generator were also considered. A resistant thermometer was used to measure heat in the enclosure for the 45minute experiment. The experiment wasrepeated three times to obtain average values for the temperature.

The noise measurements was obtained and results are tabulated as follows:

	INSERTION LOSS (or ABSORPTION LOSS) from distance (in metre)				
Generator with	**0.5m**	**1m**	**1.5m**	**2m**	**2.5m**
Without Enclosure	97dB	91dB	88dB	85dB	82dB
GFRP	85dB	80dB	76dB	72dB	69dB
GFRP +Egg Shell	84dB	78dB	74dB	71dB	66dB
GFRP +Prosopis Julifora	85dB	81dB	78dB	74dB	67dB
GFRP + SCB	87dB	81dB	77dB	74dB	71dB
GFRP + Water hyacinth	86dB	83dB	79dB	74dB	72dB
GFRP + Human Hair	**82dB**	**77dB**	**73dB**	**69dB**	**65dB**

V. Conclusion

It is evident that GFRP[4] + Human hair matrix composite hold high sound absorption coefficient . The amount of noise reduction or attenuation offered by the enclosure is measured by the difference in sound levels before and after the enclosure (or any other form of control) is fitted. A good enclosure will reduce noise levels by between 10dB(A) and 30dB(A), which was exhibited by GFRP reinforced with Human hair matrix ,epoxy resin and hardener..

References

[1] Sehrndt, G. A., Parthey, W. and Gerges, S. N. Y.. Noise sources. Retrieved August 3,2012 from https://www.who.int/occupational_health/publications/noise5.pdf (2006).

[2] Atolagbe, A.M.O and Tanimowo.Noise Pollution in Nigeria Urban Centres. A Focus onOgbomoso Town. Urban Environment Sustainability:Interventions and Responses,Akure S. Publishers, pp 77-87. (2006).

[3] Evelyn, M. I. T. and Thomas, T., Environmental Pollution In Nigeria: The Need For Awareness Creation For Sustainable Development,4(2), 5–10. (2013).

[4] Market Research Future (MRFR), Report 2019,Link:https://www.marketresearchfuture.com/reports/glass-fiber-reinforced-plastic-gfrp-market-5004